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MEASURING EQUIPMENT FOR FIELD INVESTIGATIONS ON NEAR SURFACE WAVE FORCES

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Summary

Two field investigation programmes on simultaneous wave force and water particle velocity measurements are described with reference to tubular members subjected to offshore and near shore wave kinematics.

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INTRODUCTION

For want of anything better MORISON's equation is still used for the calculation of wave forces on circular cylindrical structural members. Hence, until now many experiments in the laboratory or in the field are based on it, however, in such a way that only water level deflexions and wave forces on a test section are measured, whereas velocities and accelerations are determined using some suitable wave theory. As is well known this procedure turned out to be one of the reasons for the wide range of scatter in the reported force coefficients.
DEAN 1 has pointed out the necessity of also measuring undisturbed flow characteristics down in the fluid. To the author's knowledge this was recently done only by KIM and HIBBARD 2 measuring the local water particle velocities in a full scale experiment. In a laboratory high enough REYNOLDS's numbers were only obtained applying special model techniques (for instance SARPKAYA [3], HOGBEN [4] , YAMAMOTO and NATH [5]). It remains, however, still a question how well the respective results apply to real wave motion and especially to irregular waves with varying directions of propagation.

Being also aware of some more uncertainties arising from:

different roughness characteristics due to marine fouling,

the coincident presence of wave and (tidal and wind induced) currents,

different shapes of test sections (vertical or inclined),

different wave kinematics (deep versus shallow water) etc.

the authors started two field investigation programmes which are sponsored by the GERMAN MINISTRY OF RESEARCH AND TECHNOLOGY (MTK 0053) and the GERMAN RESEARCH FOUNDATION (Sonderforschungsbereich 79, C5) respectively.
Because of the substantially differing kinematics of deep and shallow water waves, one project (MTK) is being carried out on the GERMAN RESEARCH PLATFORM "Nordsee" about 100 km offshore in a water depth of approx. 30 m, and the other one (C5) on the island of NORDERNEY on the GERMAN NORTH SEA COAST. Both investigation programmes are at first restricted to the measurement of near surface wave forces (derived from the measured pressure distributions on the circumference of tubular members), and water level deflexions (waves), and the measurement and analysis of the ambient flow characteristics including tidal, wind and wave induced currents.
In the future these research programmes will be extended. As regards the offshore programme (MTK), this will be completed by the measurement of directional spectra (from an array of 3 sonar devices), whereas the near shore measuring configuration (C5) will be combined with measurements of additional forces exerted by wave spray loadings, see FÜHRBÖTER [6].
At present the MTK-project deals with the wave loadings exerted on an inclined member of a platform leg, whereas the near shore measuring configuration (C5) consists of a vertical pile structure for the force measurement and a satellite measuring station for the measurement of water level deflexions and particle velocities.
Because of the lack of space here, only the test structures and measuring devices subjecte to the waves are described in the following, whereas the synchronous signal transfer and data processing is similar to that reported by FUHRBOTER and BUSCHING [7]. It need only be mentioned here that different analyzing techniques will be used in the time domain as well as in the frequency domain. In particular the cross power spectra, transfer functions and coherence functions between any two signals will be calculated.

OFFSHORE MEASURING CONFIGURATION

As may be seen from the sketch of the measuring devices (Fig. 1) the test section consists of a packing ring clamped on a member of a platform leg which is inclined 30.225° with reference to the vertical axis. This tubular structure (5 m long, 1.92 m diameter) contains 24 KISTLER-pressure transducers on its circumference centered about 5m below mean low water spring (MLWS).
In the same depth of water there are 3 two-component electromagnetic COLNBROOK-current meters (No. 1 - 3) oriented in such a way (angular spaced 22.5° and 2.5 m distant from the test section), that the particle velocities in certain vertical planes containing the respective main wave propagation direction can be determined from the measurements to a high degree of certainty. For the direct measurement of the wave propagation direction and the phase velocities the current meters No. 4 and 4' are used, each measuring two velocity components in a horizontal plane 3.5 m below MLWS.

Finally, only 2 m below MLWS there is a third horizontal measuring plane again containing 3 current meters (No. 1', 2' and 3') for another measurement of the water particle kinematics in vertical planes with reference to the above mentioned current meter positions No. 1, 2 and 3.
The corresponding water level deflexions are measured at a certain distance from the test section by a BAYLOR wave staff, see Fig. 2, whereas additional wave data can be received from another set of 3 sonar devices fixed to different members of the platform structure, see [8].

4. NEAR SHORE MEASURING CONFIGURATION

Fig. 4 shows the measuring facilities located about 120 m distant from the shoreline on a slightly inclined beach $\gamma = 1 : 35$.
The vertical pile structure (diameter 0.70 m) consists of 3 parts connected by flanged coupling joints.
The bearing member driven some 7 m into the sea bed also contains two cable inlet structures, whereas the actual test section is installed in the center of the middle part at a water depth NSL + 0.70 m. For the measurement of the pressure distribution here there are 16 KISTLER transducers distributed on the circumference of a tubular member which is fixed to a cantilever supporting structure. The total force (magnitude and direction) can also thus be measured directly by some strain gauges attached to the cantilever.
The upper part of the pile extends to a height of NSL + 10 m which is more than 5 m beyond the highest measured storm tide still water level.
On top of the pile there is a working platform and a junction box where the submarine cables are connected to the cables of the measuring devices.
At a distance of 5.0 meters from the measuring pile there is a pile supported satellite measuring station provided with 4 electromagnetic 2-component NSW-current meters and 2 KISTLER pressure devices for the measurement of the water particle kinematics (in horizontal and vertical planes) and water level deflexions respectively.
In the future this programme will be extended to the measurement of the total behaviour of the structure (total wave forces and pile oscillations) especially under storm surge conditions.

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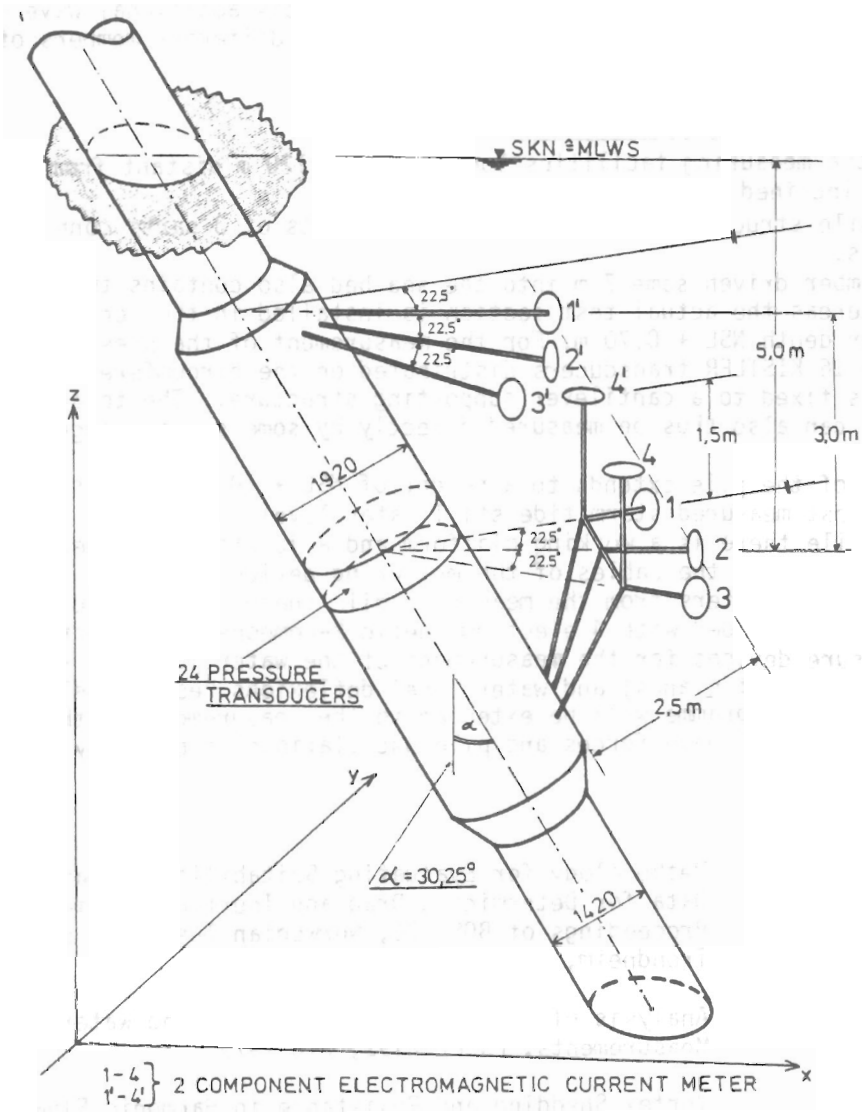

Fig. 1: SKETCH OF THE OFFSHORE MEASURING CONFIGURATION

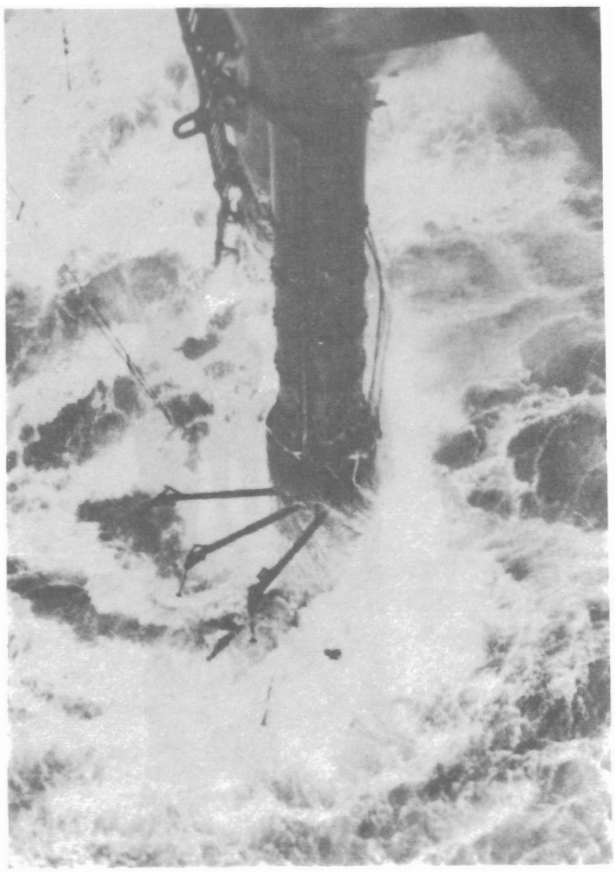

Fig. 2: TEST SECTION CLAMPED ON AN INCLINED MEMBER OF THE PLATFORM LEG TO BE SEEN AT AN EXTREMELY LOW TIDE WATER LEVEL AT STORM CONDITIONS.
BAYLOR WAVE STAFF ON THE LEFT HAND SIDE.

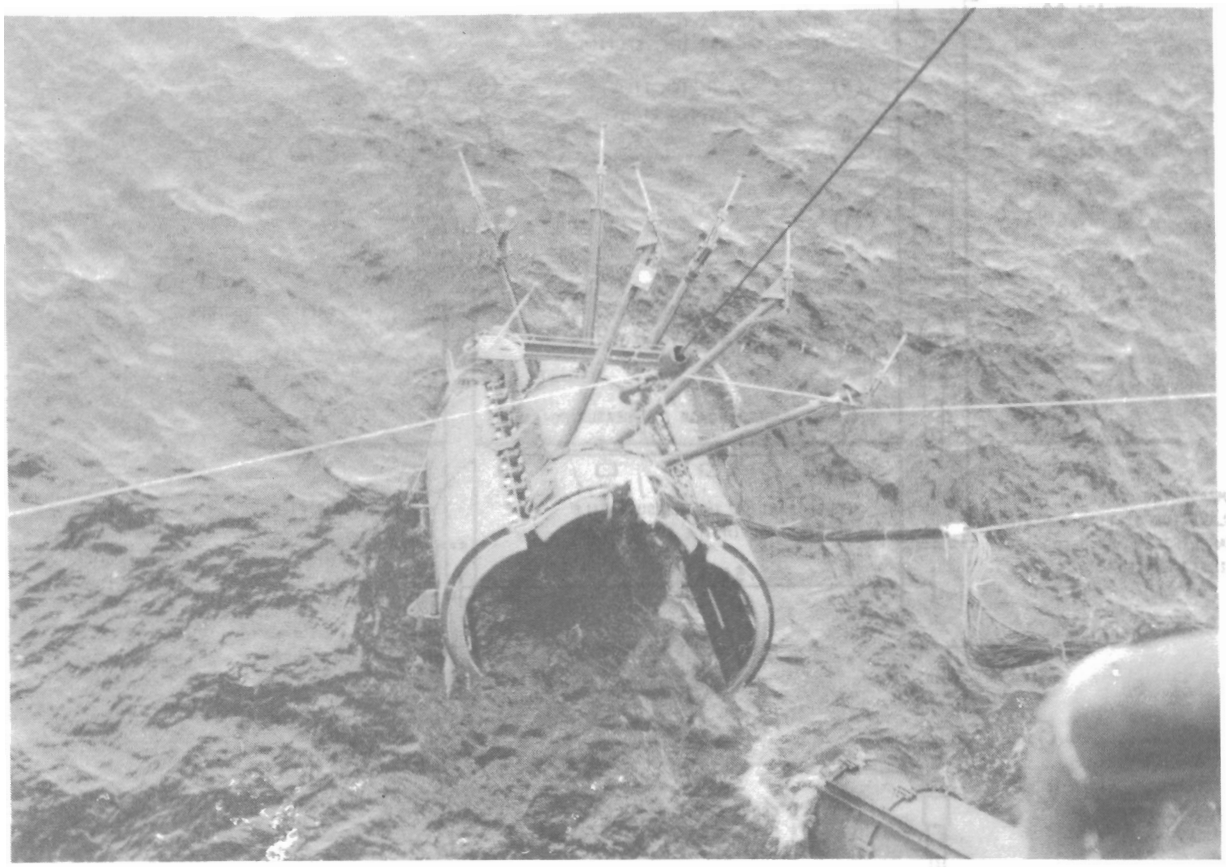

Fig. 3: LOWERING PROCESS AND INSTALLATION OF THE TEST SECTION. 1.92 m-DIAMETER PACKING RING CONTAINING 24 PRESSURE TRANSDUCERS AND 8 TWO-COMPONENT CURRENT METERS FIXED TO CANTILEVERS

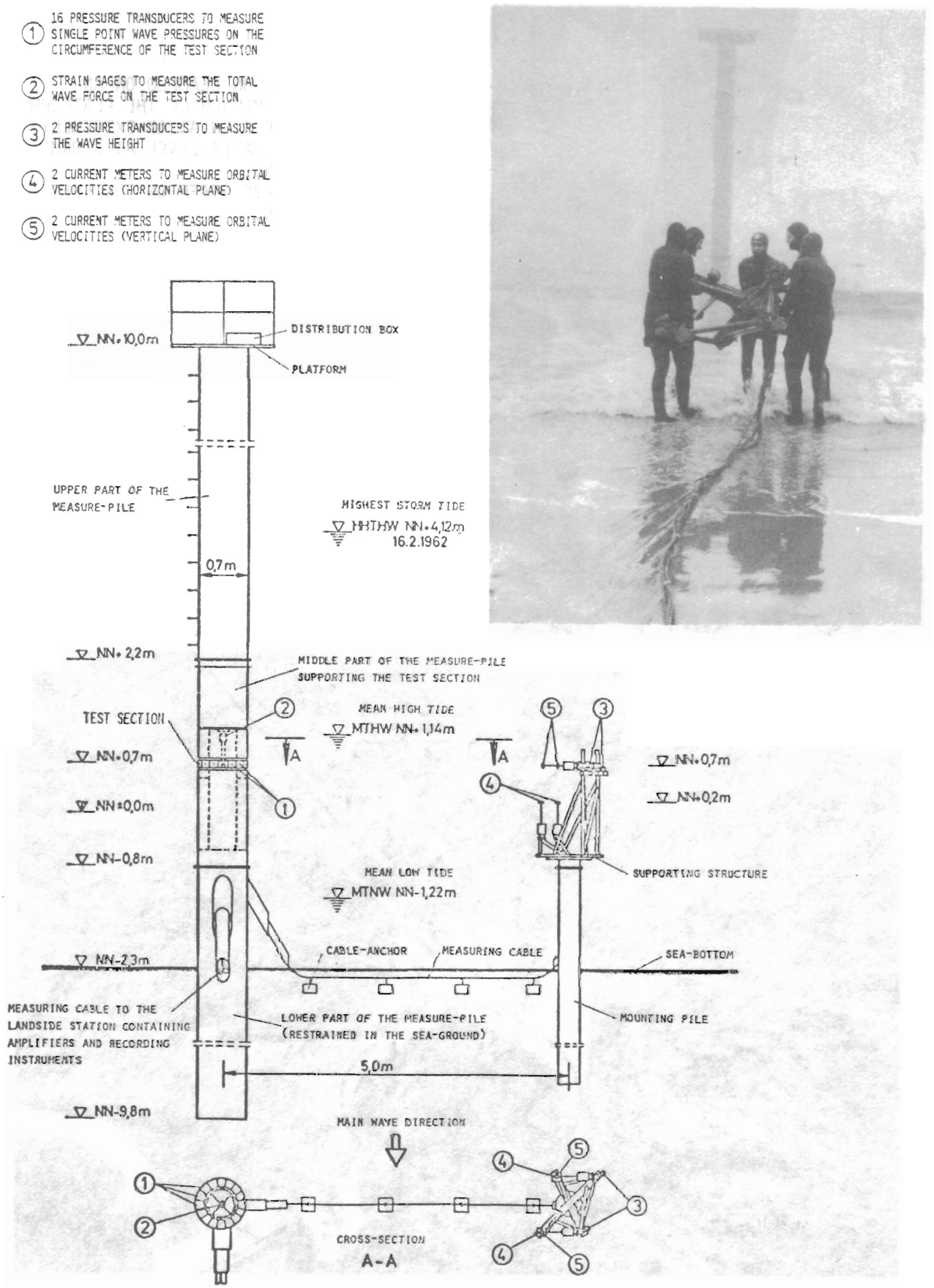

FIG. 4: NEAR SHORE MEASURING CONFIGURATION